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(54) **MULTI-DVR MEDIA CONTENT ARBITRATION**

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(51) **Int. Cl.**

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H04N 7/16	(2011.01)
H04N 21/41	(2011.01)
H04N 21/414	(2011.01)
H04N 21/4147	(2011.01)
H04N 21/433	(2011.01)

(Continued)

(52) **U.S. Cl.**

CPC ***H04N 7/163*** (2013.01); ***H04N 21/4135*** (2013.01); ***H04N 21/4147*** (2013.01); ***H04N 21/41422*** (2013.01); ***H04N 21/4334*** (2013.01); ***H04N 21/43615*** (2013.01); ***H04N 21/4583*** (2013.01); ***H04N 21/84*** (2013.01)

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CPC H04N 21/43615; H04N 21/4135; H04N 21/4334; H04N 7/163; H04N 21/41422; H04N 21/4147; H04N 21/4583; H04N 21/84

USPC 709/219, 226; 725/78, 83, 89, 93, 96, 725/100, 102, 133, 141, 29

See application file for complete search history.

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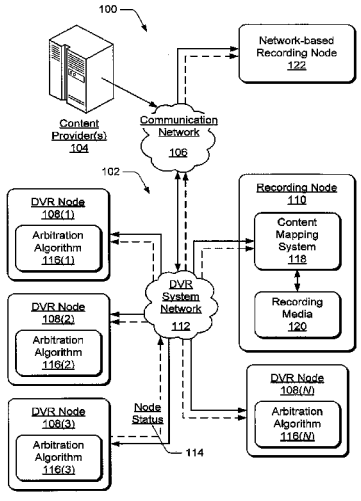
(57) **ABSTRACT**

Multi-DVR (digital video recorder) media content arbitration is described. In an embodiment, client devices are each a node of a multi-DVR system where the nodes are implemented for communication with each other. An arbitration algorithm can arbitrate media content rendered by the client devices so as not to exceed a media content usage capacity of the multi-DVR system. Each of the client devices of the multi-DVR system can communicate status messages to each of the other client devices to indicate rendered media content, and can receive the status messages from each of the other client devices. Each of the client devices can also implement the arbitration algorithm to independently determine which of the client devices has lowest priority media content that can be terminated to provide capacity for higher priority media content at one of the client devices of the multi-DVR system.

20 Claims, 7 Drawing Sheets



(51) **Int. Cl.**

H04N 21/436	(2011.01)
H04N 21/458	(2011.01)
H04N 21/84	(2011.01)

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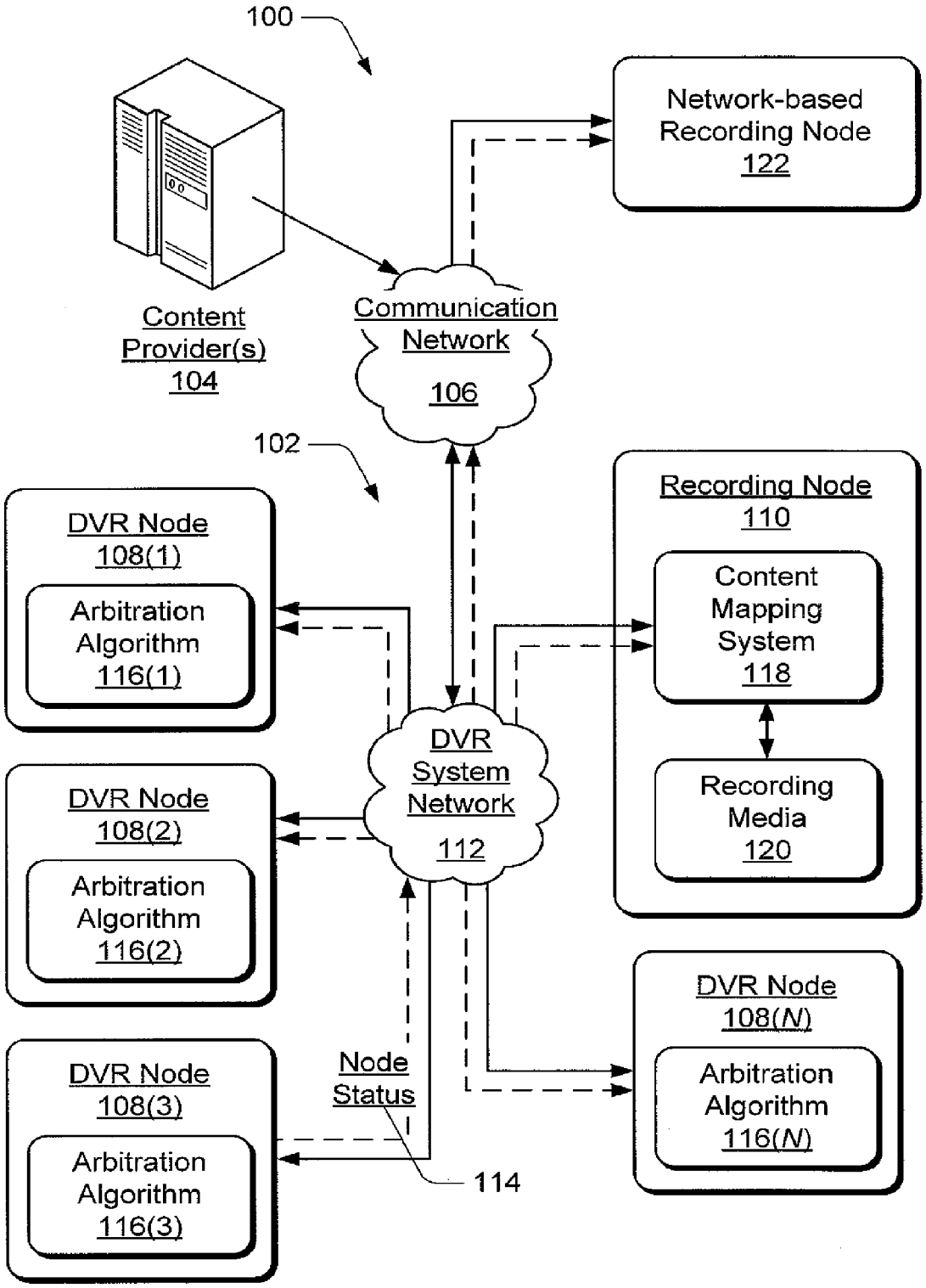
100
Network-based Recording Node 122
Content Provider(s) 104
Communication Network 106
102
DVR Node 108(1)
Arbitration Algorithm 116(1)
Recording Node 110
Content Mapping System 118
DVR System Network 112
Recording Media 120
DVR Node 108(2)
Arbitration Algorithm 116(2)
DVR Node 108(N)
Arbitration Algorithm 116(N)
DVR Node 108(3)
Arbitration Algorithm 116(3)
Node Status
114

Fig. 1

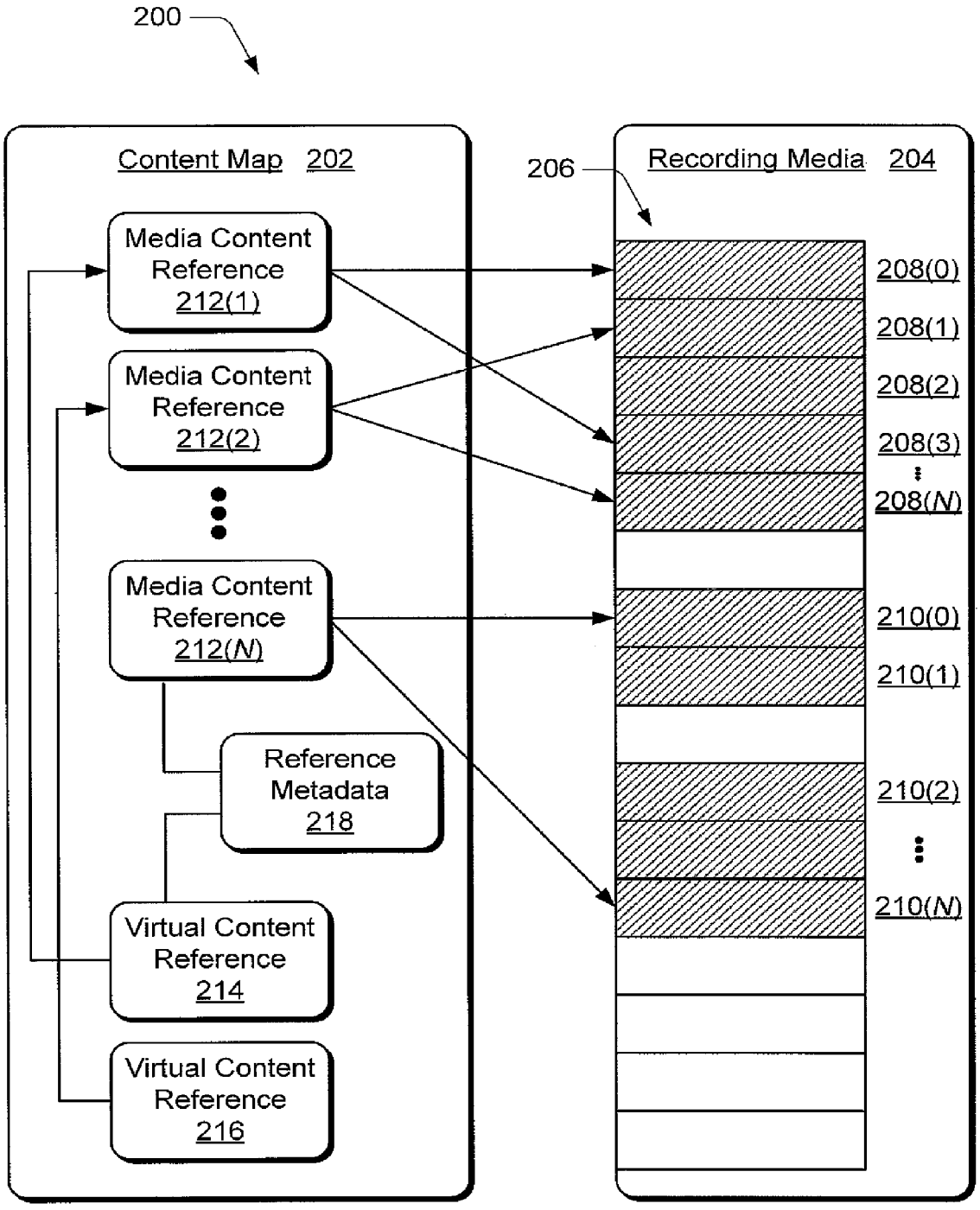
200
Content Map 202
206
Recording Media 204
Media Content Reference 212(1)
Media Content Reference 212(2)
Media Content Reference 212(N)
Reference Metadata 218
Virtual Content Reference 214
Virtual Content Reference 216
208(0)
208(1)
208(2)
208(3)
208(N)
210(0)
210(1)
210(2)
210(N)

Fig. 2

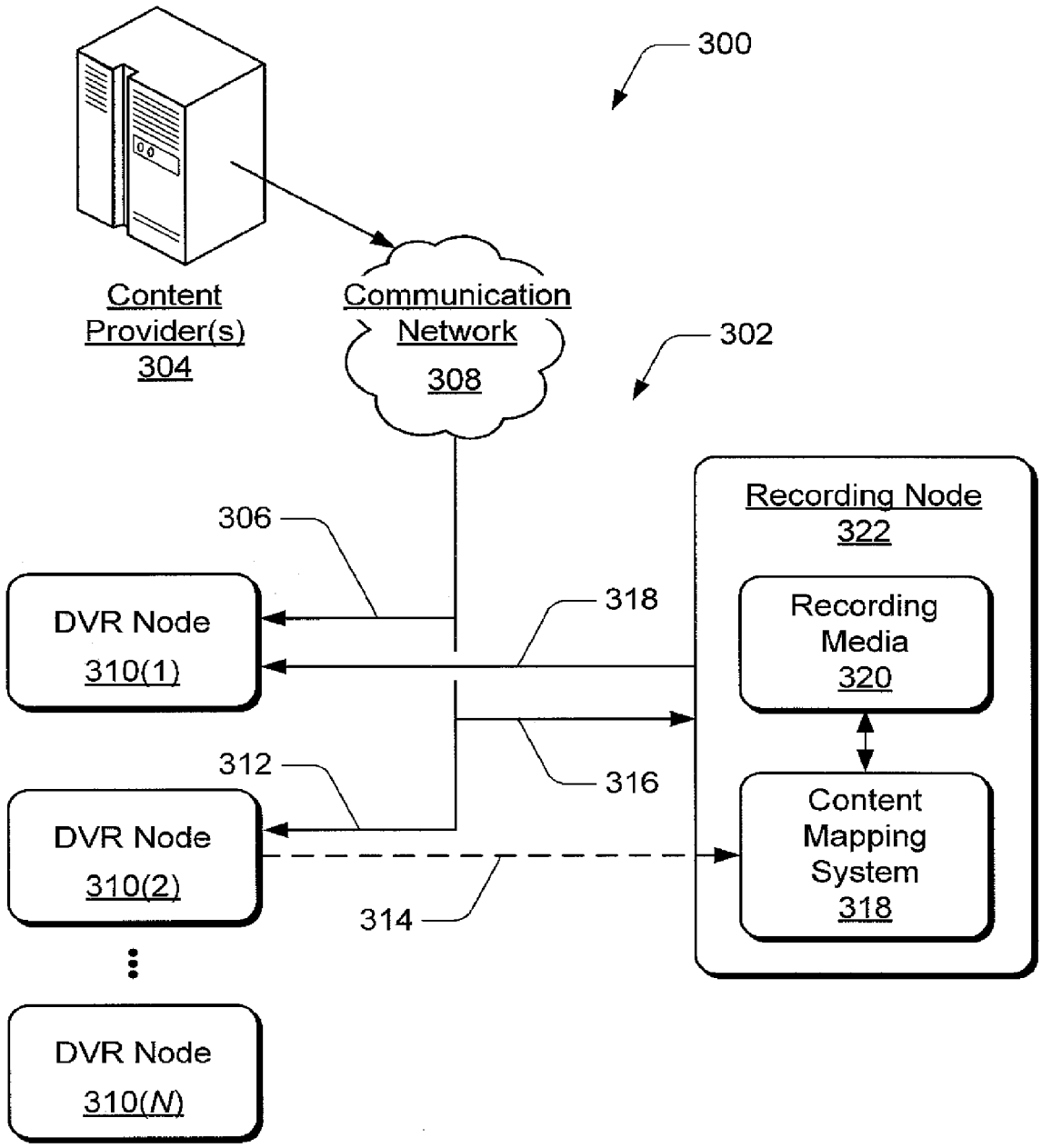
300
Content Provider(s) 304
Communication Network 308
302
Recording Node 322
306
318
DVR Node 310(1)
Recording Media 320
312
316
DVR Node 310(2)
Content Mapping System 318
314
DVR Node 310(N)

Fig. 3

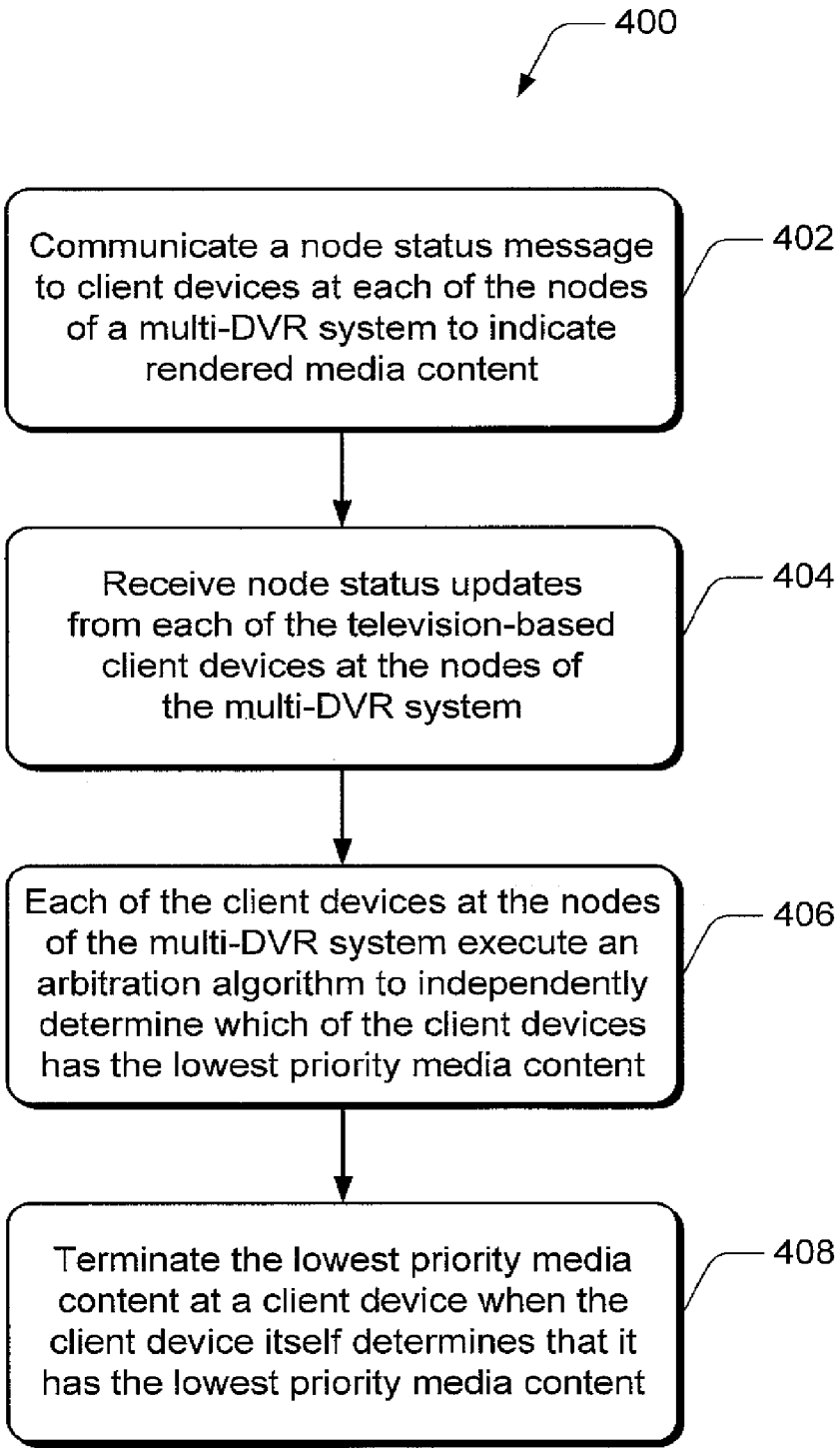
400
Communicate a node status message to client devices at each of the nodes of a multi-DVR system to indicate rendered media content
402
Receive node status updates from each of the television-based client devices at the nodes of the multi-DVR system
404
Each of the client devices at the nodes of the multi-DVR system execute an arbitration algorithm to independently determine which of the client devices has the lowest priority media content
406
Terminate the lowest priority media content at a client device when the client device itself determines that it has the lowest priority media content
408

Fig. 4

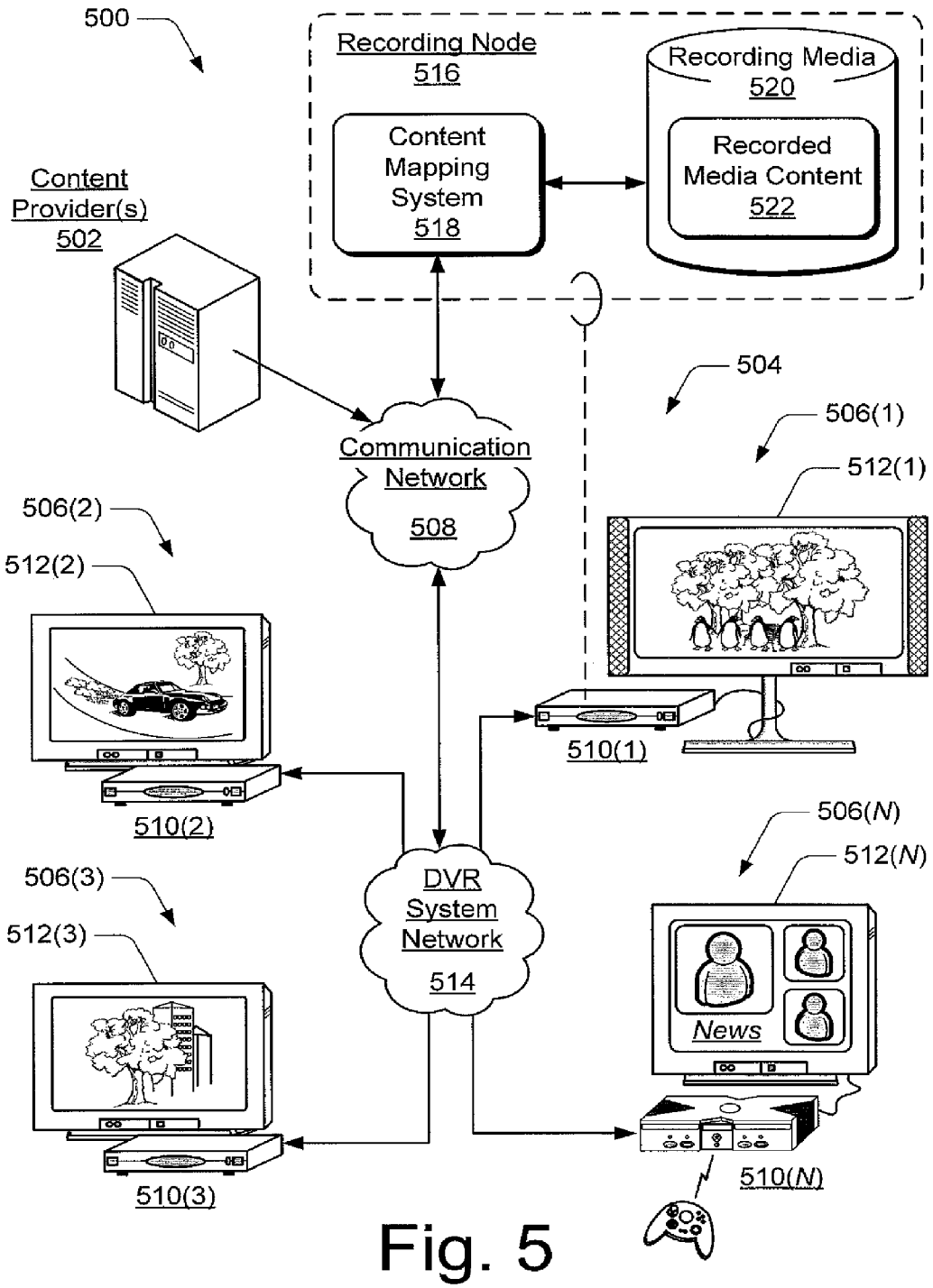
500
Recording Node
516
Recording Media
520
Content
Mapping
System
518
Recorded
Media Content
522
Content
Provider(s)
502
504
506(1)
512(1)
Communication
Network
508
506(2)
512(2)
510(1)
510(2)
506(3)
512(3)
DVR
System
Network
514
506(N)
512(N)
News
510(3)
510(N)

Fig. 5

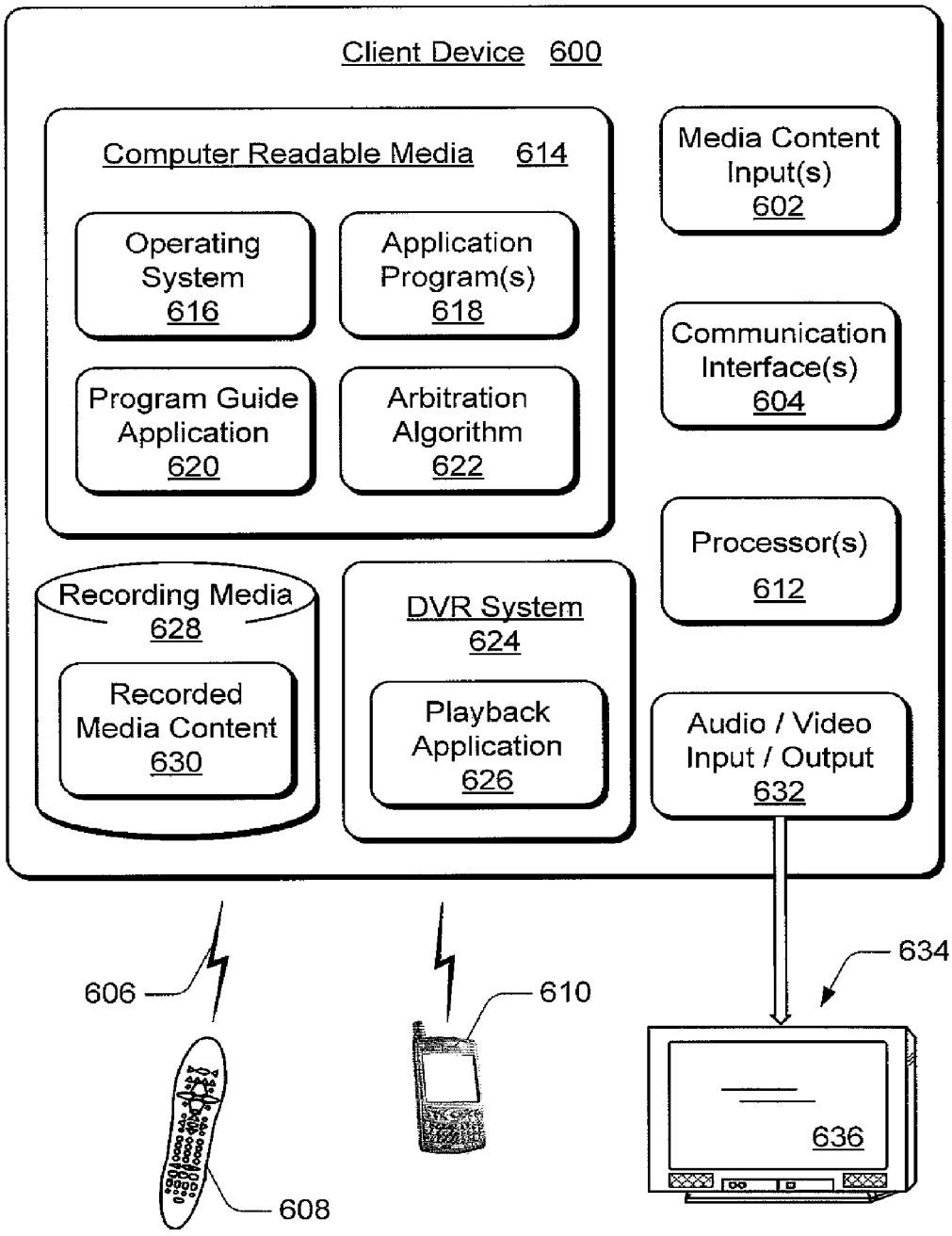
Client Device 600
Computer Readable Media 614
Operating System 616
Application Program(s) 618
Program Guide Application 620
Arbitration Algorithm 622
Media Content Input(s) 602
Communication Interface(s) 604
Processor(s) 612
Recording Media 628
Recorded Media Content 630
DVR System 624
Playback Application 626
Audio / Video Input / Output 632
606
610
634
608
636

Fig. 6

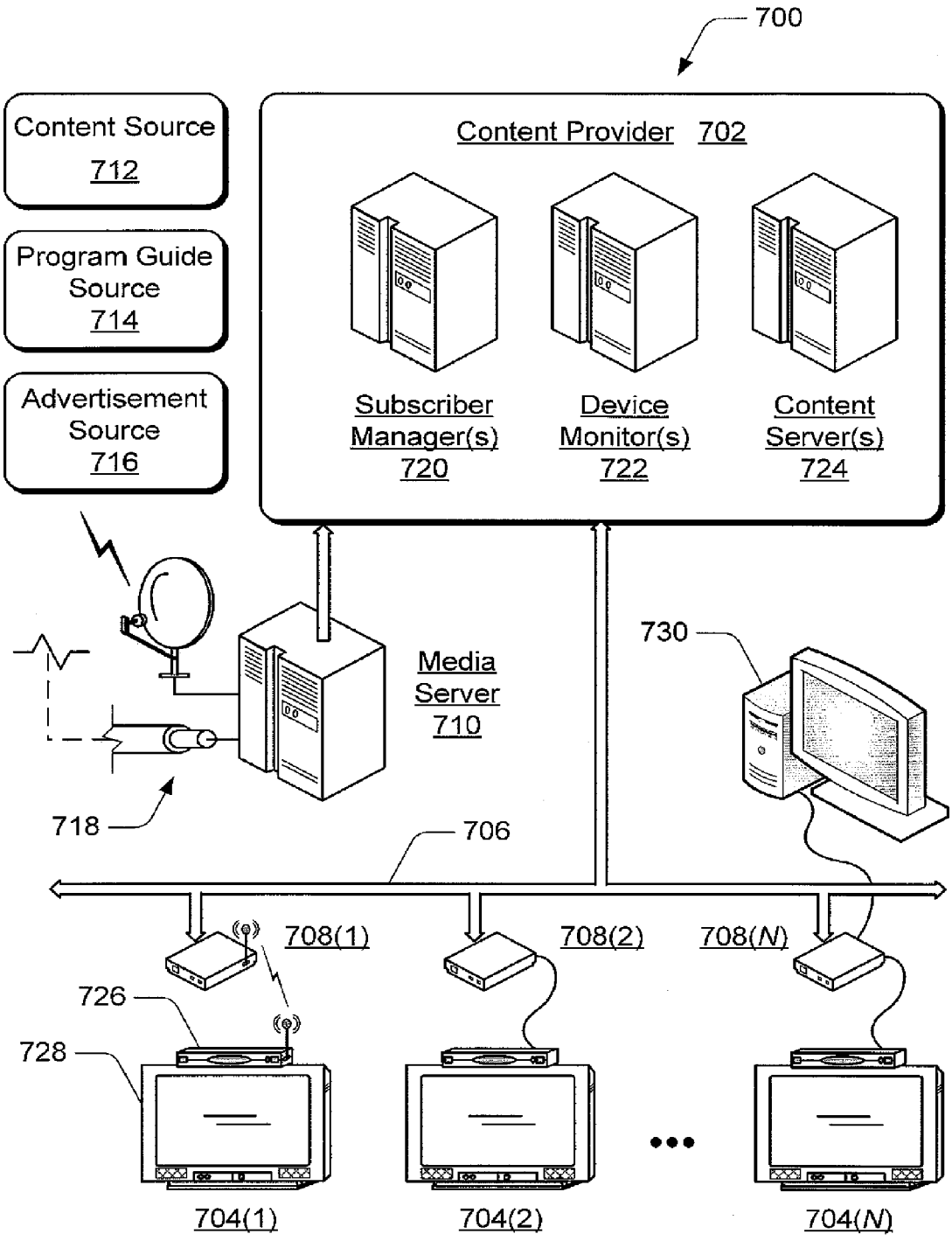
700
Content Source
712
Program Guide
Source
714
Advertisement
Source
716
Content Provider 702
Subscriber
Manager(s)
720
Device
Monitor(s)
722
Content
Server(s)
724
Media
Server
710
730
718
706
708(1)
708(2)
708(N)
726
728
704(1)
704(2)
704(N)

Fig. 7

MULTI-DVR MEDIA CONTENT ARBITRATION

BACKGROUND

Television viewing is increasingly on-demand to deliver requested media content to viewers. On-demand media content can include any type of recorded media, such as television programs, recorded programs, on-demand videos, and pay-per-view movies, any of which viewers can request for viewing when convenient rather than at a scheduled broadcast time. As on-demand media content is requested more often and by an increasing number of viewers, content providers face an increasing need to provide adequate session capacity to timely deliver the requested media content with a high quality of service.

A typical household may have four, five, or more, television viewing areas and/or rooms with televisions, most of which consumers expect to have television content provided by a television programming content provider. In an IP-based television (IPTV) system, a client device does not include a physical tuner like a conventional television set-top box, for example. Rather the television programming content and other media content is delivered to the household as IP-based data via a communication network.

In a multi-room viewing system, a primary device typically receives the television programming and other media content as the IP-based data, and then allocates the content to the other television system client devices of the viewing system. The primary device manages viewing and recording conflicts for the viewing system, such as recording times and bandwidth conflicts between the various data streams that are allocated to the other client devices and to viewer requested actions, such as a request for a data stream to view live television, receive video on-demand, listen to an audio channel, and the like.

The primary device of a multi-room viewing system also controls or manages the DVR (digital video recorder) functionality and utility in the overall system because the other client devices do not have the same DVR functionality and utility as the primary device in the system. If the primary device of a multi-room viewing system is missing or taken out of service, the other client devices of the viewing system may be rendered unusable, or unable to manage bandwidth and media content allocation conflicts.

SUMMARY

This summary is provided to introduce simplified concepts of multi-DVR (digital video recorder) media content arbitration which is further described below in the Detailed Description. This summary is not intended to identify essential features of the claimed subject matter, nor is it intended for use in determining the scope of the claimed subject matter.

In an embodiment of multi-DVR media content arbitration, client devices are each a node of a multi-DVR system where the nodes are implemented for communication with each other. An arbitration algorithm can arbitrate media content rendered by the client devices so as not to exceed a media content usage capacity of the multi-DVR system. Each of the client devices of the multi-DVR system can communicate status messages to each of the other client devices to indicate rendered media content, and can receive the status messages from each of the other client devices. Each of the client devices can also implement the arbitration algorithm to independently determine which of the client devices has lowest priority media content that can be terminated to provide capacity for higher priority media content at one of the client devices of the multi-DVR system.

In other embodiment(s) of multi-DVR media content arbitration, each of the client devices of the multi-DVR system implement the arbitration algorithm to arbitrate media content usage so as not to exceed a bandwidth capacity and/or a maximum number of media content streams of the multi-DVR system. Arbitrating the media content can include prioritizing a more recent media content tune at one client device over a previous media content tune at a different client device to determine which of the client devices has the lowest priority media content that can be terminated. Further, a client device having the lowest priority media content can be determined by a duration of rendered media content at a client device without an indication, such as a remote control input, that a viewer is watching the media content.

BRIEF DESCRIPTION OF THE DRAWINGS

The same numbers are used throughout the drawings to reference like features and components:

FIG. **1** illustrates an example environment in which embodiments of multi-DVR media content arbitration can be implemented.

FIG. **2** illustrates an example content mapping system in which embodiments of multi-DVR media content arbitration can be implemented.

FIG. **3** illustrates an example of media content transition utilizing the example content mapping system shown in FIG. **2**.

FIG. **4** illustrates example method(s) for multi-DVR media content arbitration.

FIG. **5** illustrates an example IP-based television (IPTV) system in which embodiments of multi-DVR media content arbitration can be implemented.

FIG. **6** illustrates various components of an example client device in which embodiments of multi-DVR media content arbitration can be implemented.

FIG. **7** illustrates various devices and components in an example entertainment and information system in which embodiments of multi-DVR media content arbitration can be implemented.

DETAILED DESCRIPTION

Multi-DVR (digital video recorder) media content arbitration is described for a multi-DVR system that includes any number of DVR nodes of the system, as well as recording node(s). Client devices are each a node of the multi-DVR system where the nodes are implemented for communication with each other to act and make decisions on behalf of other nodes, for the overall common good of the multi-DVR system, and based on the state of individual nodes and/or based on the state of the multi-DVR system. In a multi-DVR environment, limited available bandwidth to share media content stream resources among the node devices can be arbitrated by the devices themselves.

Each node of the multi-DVR system can communicate a node status message to the other client devices at the respective nodes of the multi-DVR system, and each node of the system can receive the node status messages from the other client devices in the system. Each of the client devices can also implement an arbitration algorithm to arbitrate media content rendered by the client devices so as not to exceed a media content usage capacity of the multi-DVR system, such as a bandwidth capacity and/or a maximum number of media content streams of the multi-DVR system. Each of the client

devices can then independently determine which of the client devices has lowest priority media content that can be terminated to provide capacity for higher priority media content at one of the client devices of the multi-DVR system.

While aspects of the described systems and methods for multi-DVR media content arbitration can be implemented in any number of different computing systems, environments, entertainment systems, and/or configurations, embodiments of multi-DVR media content arbitration are described in the context of the following example systems and environments.

FIG. **1** illustrates an example environment **100** in which embodiments of multi-DVR media content arbitration can be implemented. The environment **100** includes a multi-DVR system **102**, such as may be implemented in a household as a viewing system that has several viewing areas or different rooms for viewing television programs. An example of a multi-DVR system is described with reference to the example IP-based television (IPTV) system shown in FIG. **5**. The multi-DVR system **102** is configured for communication with any number of different content provider(s) **104** via a communication network **106**.

Any of the systems and/or devices can be configured for network access in any number of embodiments and varieties of implementation. The communication network **106** can be implemented as any one or combination of a wide area network (e.g., the Internet), a local area network (LAN), an intranet, an IP-based network, broadcast network, a public telephone network, a wireless network, or other media content distribution network. Additionally, communication network **106** can be implemented using any type of network topology and any network communication protocol, and can be represented or otherwise implemented as a combination of two or more networks.

The multi-DVR system **102** includes DYR nodes **108**(**1**-N) and, optionally, a recording node **110**, all of which communicate with each other via a DVR system network **112**. In an embodiment, the DVR nodes **108**(**1**-N) can each be implemented to include a client device and/or can be implemented as a client system as described with reference to the example IP-based television (IPTV) system shown in FIG. **5**. A client system can include a client device and a display device, such as any type of television, monitor, LCD, or similar television-based display system that together renders audio, video, and/or image data.

A DVR node **108** may also be implemented as any one or combination of a client device, a gaming console, or as any other computing-based device, such as a desktop computer, a portable computer, a set-top box, a digital video recorder (DVR) and playback system, an appliance device, a gaming system, and/or as any other type of computing-based client device. A client device at a node **108** of the multi-DVR system **102** may also be associated with a user (i.e., a person) and/or an entity that operates a client device such that the client device describes logical clients that include users, software, and/or devices.

As a television system client device, a node **108** of the multi-DVR system **102** can be implemented with one or more processors, a communication module, memory components, and a content rendering system which can be implemented as computer executable instructions and executed by the processor(s) to implement embodiments of multi-DVR media content arbitration. Additionally, a client device at a node **108** of the multi-DVR system **102** may be implemented with any number and combination of differing components as further described below with reference to the example client device shown in FIG. **6**.

A television system client device at a node **108** of the multi-DVR system **102** can receive programs, associated program content, various forms of media content, program guide data, advertising content, and other types of media content from the content provider(s) **104** via the communication network **106**. Media content can include television programs (or programming) which may be any form of programs, commercials, music, movies, and video on-demand media content. Other media content can include recorded media content, interactive games, network-based applications, and any other similar audio, video, and/or image content. In addition, media content in general may include music streamed from a computing device to a client device, such as a television set-top box, and may also include video on-demand media content delivered from a server, and any other audio, video, and/or image content received from any type of media content source.

In various embodiments of multi-DVR media content arbitration, each of the nodes **108**(**1**-N) of the multi-DVR system **102** can communicate with each other to act and make decisions on behalf of the other nodes **108**(**1**-N), for the overall common good of the multi-DVR system **102**, and based on the state of individual nodes **108** and/or based on the state of the multi-DVR system **102**. The nodes **108**(**1**-N) can communicate with each other to indicate such information as what type of media content a node is rendering, a bit rate of the service, an indication of whether the service is a multicast or unicast (such as a video on-demand), recording status, playback status, operational status, recording requests, and/or any other type of node-based information and requests. A node **108** of the multi-DVR system **102** can then make an operational decision based on what it knows about the operational status of the other node(s), rather than waiting for an instruction to make an operational decision. With this "awareness" approach, the multi-DVR system **102** can be implemented without a master device having to control each of the other client devices at the nodes **108**(**1**-N) of the multi-DVR system **102**.

Each DVR node **108** of the multi-DVR system **102** can communicate a node status message **114** that is unicast to all of the other DVR nodes **108**(**1**-N) and to the recording node **110**. In an embodiment, a node status message can represent various in-band metadata sources. In this example, the node status message **114** is communicated from DVR node **108**(**3**) (represented by the dashed lines) to all of the other DVR nodes **108**(**1**-N) and to recording node **110** via the DVR system network **112**. Additionally, each DVR node **108** of the multi-DVR system **102** can receive a node status update message from each of the client devices at the DVR nodes **108**(**1**-N) of the multi-DVR system **102** for real-time updates of media content information at all of the nodes in the system.

Each node **108**(**1**-N) of the multi-DVR system **102** is network aware and decisions are based on the aggregate needs of the client devices which can all have the same policies. In this example, the client devices at the nodes **108**(**1**-N) of the multi-DVR system **102** each include a respective instantiation of an arbitration algorithm **116**(**1**-N). As described above, every node **108**(**1**-N) has context of every other node in the system from the node status messages, and based on knowing the aggregate bandwidth and/or media content stream capacity of the overall service, can make decisions about whether it can tune to obtain a resource, such as a media content stream, and thereby deprive another client device in the system of the resource. For example, rather than a first client device being commanded or instructed from another of the client devices to detune from a media content stream, the

first device will independently determine that it has to detune from a media content stream based on the aggregate system status.

For example, the multi-DVR system **102** may have three high definition televisions, one each at the nodes **108**(**1**-**3**), but bandwidth for only two high definition services. If two of the televisions are tuned to receive high definition media content, and the third television is then initiated to also receive high definition media content, the system **102** has to determine whether to allocate the media content stream from either of the other two nodes. The arbitration algorithm **116** at each of the nodes **108**(**1**-N) of the multi-DVR system **102** can be implemented to arbitrate these and other types of decisions in various embodiments of multi-DVR media content arbitration.

The arbitration algorithm **116** at each of the nodes **108**(**1**-N) of the multi-DVR system **102** can be implemented to arbitrate media content rendered by the node client devices so as not to exceed a media content usage capacity of the multi-DVR system **102**, such as a bandwidth capacity and/or a maximum number of media content streams in the multi-DVR system **102**. The arbitration policies can be based on a priority of the media content being rendered at the different node client devices in the system. For example, each node **108**(**1**-N) of the multi-DVR system **102** can independently determine the same client device that has the lowest priority media content which can be terminated to provide capacity for higher priority media content at one of the other node client devices of the multi-DVR system **102**. Only the client device that is rendering the lowest priority media content acts on its own accord to release the resource such that the higher priority media content can be rendered at a different node of the multi-DVR system **102**.

The priority of media content being rendered at the nodes **108**(**1**-N) of the multi-DVR system **102** can be ordered from a high priority to a low priority for recorded media content, on-demand media content, live media content (such a live television and music streams), and then picture-in-picture media content. The rendered media content can then also be prioritized based on a more recent media content tune at a first client device over a previous media content tune at a second client device.

Additionally, the arbitration algorithm **116** can determine the lowest priority media content by a duration of rendered media content without an indication that a viewer is watching the media content at a node client device. An indication that a viewer is watching media content at a node **108** of the system **102** can include any type of viewer action at the node and/or a remote control input, such as a channel change, a volume adjust, a fast-forward command, a pause command, an information or program guide button input, or any other type of indication that a user is still watching the media content at a node **108** of the system **102**. This type of arbitration decision would presume that the lowest priority media content is being rendered at a node having the most time without any indication that a viewer is watching the media content, such as if a viewer has left the viewing area, but did not turn the television off.

As described above, the node status messages communicated between all of the nodes **108**(**1**-N) of the multi-DVR system **102** can include such information as what type of media content a node is rendering and any type of viewer input or indication that the media content being rendered at a node is being watched by a viewer. Each node **108** can broadcast its own last activity to all of the other nodes of the multi-DVR system **102** via a node status message **114**.

When the lowest priority media content is determined, the arbitration algorithm **116** can be implemented to initiate other options rather than simply detuning the node client device that is rendering the lowest priority media content. The options may include retuning the client device to a different media content stream, such as from rendering a program in high definition to rendering the program in low definition, thereby deallocating enough bandwidth such that the higher priority media content can be rendered at a different node client device of the multi-DVR system **102**.

In addition to retuning to a smaller bandwidth stream, the options can include joining another media content stream that is already in progress and/or monitoring the loss of a media content stream to determine when it would again be available. In addition (or alternatively), the arbitration algorithm **116** can be implemented to not only detune the lowest priority media content so as not to exceed the media content usage capacity of the multi-DVR system **102**, but the arbitration algorithm **116** can be implemented to determine the lowest number of media content streams to detune at any of the various nodes **108** of the system **102** so as not to exceed the media content usage capacity of the system.

The node status messages communicated between all of the nodes **108**(**1**-N) of the multi-DVR system **102** may also include a priority adjustment factor, such as an offset or multiplier, that artificially adjusts the media content priority determination at a node **108** of the system **102**. For example, the node **108**(**1**) of the multi-DVR system **102** may be user-designated as having a higher priority than the other nodes **108**(**2**-N), and have a thirty minute offset, a scaling multiplier, or other type of priority adjustment factor. The node **108**(**1**) may then be determined to have the lowest priority media content because there has been no indication for two hours that a viewer is still watching the media content being rendered at node **108**(**1**). However, if the node **108**(**1**) has a thirty minute priority adjustment factor, the arbitration algorithm **116** (at all of the nodes **108**(**1**-N) in the system **102**) can determine that the lowest priority media content is being rendered at node **108**(**2**) which has had no indication for only an hour and forty-five minutes that a viewer is still watching the rendered media content at node **108**(**2**).

To avoid oversubscribing the multi-DVR system **102** and entering into a condition where the media content usage capacity of the system would be exceeded, the arbitration algorithm(s) **116**(**1**-N) at each of the node client devices can be implemented to pre-determine what the overall system response would be to a new request for media content at one of the nodes **108**. A node at which a new request for media content is initiated can communicate a provisional tune status message to all of the other nodes **108**(**1**-N) of the multi-DVR system **102** such that the overall system response can be determined prior to the new media content being rendered at the requesting node. In an embodiment, a user interface can be provided at the requesting node **108** where a viewer intends to initiate the new request to indicate viewer options and system status, such as an indication that the new request for media content would detune another of the nodes, and providing the viewer with the option to proceed with the request or not.

In the example environment **100**, the recording node **110** of the multi-DVR system **102** includes a content mapping system **118** and recording media **120**. In an embodiment, any one or more of the client devices at the nodes **108**(**1**-N) of the multi-DVR system **102** can be implemented as the recording node **110** which includes the recording media **120** to record media content received from a content provider **104**. Alternatively (or in addition), a recording node of the multi-DVR

system **102** can be implemented as a network-based recording node **122** that the multi-DVR system **102** communicates with via the communication network **106**. The network-based recording node **122** can also include a content mapping system and a recording media.

A recording node **110**, **122** can record media content with the recording media for any one or more of the DVR nodes **108** of the multi-DVR system **102**. For example, a client device at a node **108** of the multi-DVR system **102** can initiate a record request to have media content recorded. A record request can be initiated for a scheduled recording or to record and provide a pause buffer for a DVR node **108** of the multi-DVR system **102**. The recording node **110** can receive the record request and record the media content such that the client device at the DVR node **108** can access and render the recorded media content from the recording node via the DVR system network **112**. The record request from the client device at the DVR node **108** of the multi-DVR system **102** can include a media content identifier of the media content, a record start time, and a record stop time such that the recording node **110** can identify the media content when received from a content provider **104** via the communication network **106**.

FIG. **2** illustrates an example content mapping system **200** in which embodiments of multi-DVR media content arbitration can be implemented. The content mapping system **200** can be implemented as the content mapping system **118** at recording node **110** described with reference to FIG. **1**. The content mapping system **200** includes a content map **202** and one or more recording media **204** that includes memory segments **206** (also referred to as data blocks) which are each of a size that corresponds to several minutes of media content (such as video).

Media content, such as a television program, can be recorded into the memory segments **206** which are then allocated as memory segments **208**(**0**-N) that are illustrated to represent having been recorded. For example, the allocated memory segments **208**(**0**-N) can be recorded as a scheduled recording or as a pause buffer for a client device at a DVR node **108** of the multi-DVR system **102** shown in FIG. **1**. Similarly, allocated memory segments **210**(**0**-N) are illustrated to represent having been recorded to maintain media content for a client device at a node **108** of the multi-DVR system **102**. Additionally, the allocated memory segments **210**(**0**-N) illustrate that allocated memory segments do not have to be consecutive in a recording media **204**.

The content map **202** includes media content references **212**(**1**-N) that each reference to the recording media **204** to designate recorded media content that is associated with a client device at a DVR node of a multi-DVR system. A media content reference may also be mapped to different overlapping recording requests, and not just to the different client devices. In this example, media content reference **212**(**1**) references to the allocated memory segments **208**(**0**-**3**), media content reference **212**(**2**) references to the overlapping allocated memory segments **208**(**1**-N), and media content reference **212**(N) references to the allocated memory segments **210**(**0**-N).

A media content reference **212** can be implemented as a computing-based programming reference, a pointer, and/or as any other type of content mapping reference to allocated memory segments or blocks. In this example, the media content references **212**(**1**-N) are each pointers to start and end points in the physical recording media **204** over a range of the allocated memory segments. Media content references **212**(**1**) and **212**(**2**) illustrate that the media content references can be mapped to overlapping allocated memory segments of the same recording **208**(**0**-N). As such, pause buffers for different client devices can be overlapping. This provides that a viewer can tune to a channel that someone else is watching, rewind back to a previous program in that pause buffer, and select to record the program. Additionally, two different client devices can be recording the same program on the same channel, such as denoted by media content reference **212**(**1**) which references to the allocated memory segments **208**(**0**-**3**) and media content reference **212**(**2**) which references to the allocated memory segments **208**(**1**-N) such that viewers at the two different client devices each have a continuous viewing experience.

The content map **202** also includes virtual content references **214** and **216** which are each a reference to a media content reference **212** such that recorded media content associated with a client device via the media content reference is also associated with an additional client device via the virtual content reference. For example, virtual content reference **214** references to media content reference **212**(**1**) which references to the allocated memory segments **208**(**0**-**3**). Similarly, virtual content reference **216** references to media content reference **212**(**2**) which references to the allocated memory segments **210**(**1**-N).

Virtual content references provide for multiple references to a single recording for any number of client devices at various nodes of a multi-DVR system. For example, a viewer at DVR node **108**(**1**) may tune the corresponding client device in the multi-DVR system **102** to receive and watch the media content associated with a particular television channel. In addition, the recording node **110** can begin recording a pause buffer for DVR node **108**(**1**) and a media content reference **212**(**1**) is generated to designate the recorded media content in the recording media **204** as being associated with the client device. A second viewer at DVR node **108**(**2**) may then initiate a recording of the same media content associated with the particular television channel. A virtual content reference **214** is then generated in the content map **202** which references to the media content reference **212**(**1**) such that the second client device is also associated with the recorded media content.

If the viewer at DVR node **108**(**1**) then tunes the corresponding client device to receive different media content, the recording node **110** can continue to record the media content if the client device at DVR node **108**(**2**) continues the recording. If the viewer at DVR node **108**(**2**) stops the recording, then the recording node **110** can stop recording the media content, yet maintain the recorded media content with the recording media **204**. If a viewer at yet a third DVR node **108**(**3**) also initiates a recording of the same media content associated with the particular television channel, another virtual content reference **216** is generated which also references to the media content reference **212**(**1**) such that the third client device is also associated with the recorded media content. The virtual content references **214**, **216** provide that two different DVR nodes **108** of the multi-DVR system **102** are served by the same recorded media content where the multiple content references can intersect, overlap in time, and the like.

The content map **202** also includes reference metadata **218** which, in an embodiment, corresponds to a media content reference **212** and is associated with the recorded media content designated by the media content reference. In another embodiment, the reference metadata **218** corresponds to a virtual content reference **214** and is associated with the recorded media content designated by the virtual content reference (via a media content reference).

The reference metadata **218** that corresponds to a media content reference **212** can include a time-based index to a

segment of the recorded media content where the time is an absolute time reference. The reference metadata **218** can also include attributes that are associated with the allocated memory segments, such as mapped index points from which the recorded media can be accessed and rendered, the extents or chain of allocated memory segments, a time offset within an extent, and/or any other data associated with recorded media content. The reference metadata **218** that corresponds to a virtual content reference includes attributes such as a start time and an end time of the recorded media content, and an identifier of the media content.

FIG. **3** illustrates an example of media transition **300** in which a DVR node of a multi-DVR system **302** can seamlessly switch from a live media content stream to recorded playback. In the example media transition **300**, a content provider **304** communicates a live stream of media content **306** via a communication network **308** to a DVR node **310**(**1**) of the multi-DVR system **302**. A second DVR node **310**(**2**) of the multi-DVR system **302** can also receive the live media content stream **312**, where the media content is multicast to the multi-DVR system **302**. The second DVR node **310**(**2**) can initiate **314** that the media content be recorded **316** via a content mapping system **318**, such as in a pause buffer (recording media) **320** at a recording node **322** of the multi-DVR system **302**.

The first DVR node **310**(**1**) can then transition from the content stream **306** to receive the recorded media content **318** from the recording node **322** without discontinuity of the media content. In an embodiment, the content mapping system **318** can generate a media content reference to associate the recorded media content with the second DVR node **310**(**2**) that initiates the recording. The content mapping system **318** can then generate a virtual content reference to the media content reference to also associate the recorded media content with the first DVR node **310**(**1**). The first DVR node **310**(**1**) can then transition from the content stream **306** to the recorded media content **318** based on a time-based index corresponding to both the media content of the content stream which is synchronous with the recorded media content.

Generally, any of the functions and methods described herein can be implemented using hardware, software, firmware (e.g., fixed logic circuitry), manual processing, or any combination thereof. A software implementation represents program code that performs specified tasks when executed on a computing-based processor. Example method **400** described with reference to FIG. **4** may be described in the general context of computer executable instructions. Generally, computer executable instructions can include applications, routines, programs, objects, components, data structures, procedures, modules, functions, and the like that perform particular functions or implement particular abstract data types. The methods may also be practiced in a distributed computing environment where functions are performed by remote processing devices that are linked through a communications network. In a distributed computing environment computer executable instructions may be located in both local and remote computer storage media, including memory storage devices. Further, the features described herein are platform-independent such that the techniques may be implemented on a variety of computing platforms having a variety of processors.

FIG. **4** illustrates example method(s) **400** for multi-DVR media content arbitration and is described with reference to the example environment shown in FIG. **1**. The order in which the method is described is not intended to be construed as a limitation, and any number of the described method blocks can be combined in any order to implement the method, or an alternate method.

At block **402**, a node status message is communicated to client devices at each of the nodes of a multi-DVR system to indicate rendered media content. For example, a client device at DVR node **108**(**3**) communicates a node status message **114** to all of the client devices at the other nodes **108** of the multi-DVR system **102** via the DVR system network **112**. A node status message **114** can include a media content identifier and a type of the media content being rendered at DVR node **108**(**3**).

At block **404**, node status messages are received from each of the client devices at the nodes of the multi-DVR system where the status messages indicate rendered media content. For example, DVR node **108**(**1**) receives node status updates (e.g., node status **114**) from each of the client devices at the DVR nodes **108**(**2**-N) of the multi-DVR system **102**.

At block **406**, an arbitration algorithm is executed by each of the client devices to independently determine which of the client devices has the lowest priority media content that can be terminated to provide capacity for higher priority media content at one of the other client devices of the multi-DVR system. For example, each of the client devices at the nodes **108**(**1**-N) of the multi-DVR system **102** execute the arbitration algorithm **116** to independently determine the same client device of the multi-DVR system that has the lowest priority media content that can be terminated so as not to exceed a bandwidth capacity and/or a maximum number of media content streams in the multi-DVR system **102**.

The arbitration algorithm **116** can prioritize the rendered media content at the nodes **108**(**1**-N) of the multi-DVR system **102** based on a more recent media content tune at a first client device over a previous media content tune at a second client device. Additionally, the arbitration algorithm **116** can determine the lowest priority media content by a duration of rendered media content without an indication that a viewer is watching the media content at a node client device. An indication that a viewer is watching media content at a node **108** of the system **102** can include any type of viewer action at the node, a remote control input, and/or any other type of indication that a user is still watching the media content at a DVR node **108** of the multi-DVR system **102**.

At block **408**, the lowest priority media content at a client device is terminated by the client device itself when determining that it has the lowest priority media content. Only the client device at a node **108**(**1**-N) of the multi-DVR system **102** that is rendering the lowest priority media content needs to act on its own accord to release the resource such that higher priority media content can be rendered at a different node of the multi-DVR system.

FIG. **5** illustrates an example IP-based television (IPTV) environment **500** in which embodiments of multi-DVR media content arbitration can be implemented. The IPTV environment **500** includes content provider(s) **502** and a multi-DVR system **504** that can include any number of client systems **506**(**1**-N). The multi-DVR system **504** is an example of the multi-DVR system shown in FIG. **1**, and can represent a household viewing system that has several viewing areas, such as different rooms, for viewing television programs. The multi-DVR system **504** is configured for communication with any number of the different content provider(s) **502** via a communication network **508** which, in this example, is an IP-based network. Any of the systems and/or devices can be configured for network access in any number of embodiments and varieties of implementation.

The client systems **506**(**1**-N) of the multi-DVR system **504** are representative of the DVR nodes **108**(**1**-N) of the multi-DVR system shown in FIG. **1**. The client system **506**(**1**) includes a client device **510**(**1**) and a display device **512**(**1**), such as any type of television, monitor, LCD, or similar television-based display system that together renders audio, video, and/or image data. Similarly, the client systems **506**(**2**-N) each include a respective client device **510**(**2**-N) and a respective display device **512**(**2**-N). Each client device **510** can be implemented in any number of embodiments, such as a television system set-top box, a digital video recorder (DVR) and playback system, an appliance device, a gaming system such as client device **510**(N), and as any other type of client device that may be implemented in an entertainment and information system.

Each of the client devices **510**(**1**-N) can include an instantiation of the arbitration algorithm **116** described with reference to FIGS. **1** and **4** to implement embodiments of multi-DVR media content arbitration as described herein. The client systems **506**(**1**-N) can be implemented for communication with each other via a DVR system network **514**, and may be implemented with any number and combination of differing components as further described below with reference to the example client device shown in FIG. **6**. Further, the IPTV environment **500** may be implemented with any number and combination of differing components as described below with reference to the example entertainment and information system shown in FIG. **7**.

A client system **506** at a node of the multi-DVR system **504** can receive programs, associated program content, various forms of media content, program guide data, advertising content, and other types of media content from content server(s) of the content provider(s) **502** via the communication network **508**. Media content can include television programs (or programming) which may be any form of programs, commercials, music, movies, and video on-demand movies. Other media content can include recorded media content, interactive games, network-based applications, and any other similar audio, video, and/or image content. In addition, media content in general may include music streamed from a computing device to a client device, such as a television system set-top box, and may also include video on-demand media content delivered from a server, a photo slideshow, and any other audio, video, and/or image content received from any type of media content source.

Although the data streams are not shown specifically, the arrowed communication links illustrate various data communication links which include the data streams. Additionally, the arrowed communication links are not intended to be interpreted as a one-way communication link from the DVR system network **514** to a client device **510**(**1**), for example. It is contemplated that any one or more of the arrowed communication links can facilitate two-way data communication, such as from communication network **508** to a content provider **502**.

The multi-DVR system **504** includes a recording node **516** which includes a content mapping system **518** and recording media **520** to maintain recorded media **522**. In an embodiment, any one or more of the client devices **510**(**1**-N) in the multi-DVR system **504** can be implemented as the recording node **516** (as shown by the dashed line) which includes the recording media **520** to record media content received from a content provider **502**. Alternatively (or in addition), a recording node of the multi-DVR system **504** can be implemented as a network-based recording node that the multi-DVR system **504** communicates with via the communication network **508**. In another implementation, the recording node **516** can be an independent component of the multi-DVR system **504**.

The recording node **516** can record media content with the recording media **520** for any one or more of the client devices **510**(**1**-N) of the multi-DVR system **504**. For example, a client device **510** at a node of the multi-DVR system **504** can initiate a record request to have media content recorded for a scheduled recording or to record and provide a pause buffer for the client device. The recording node **516** can receive the record request and record the media content such that the client device can access and render the recorded media content from the recording node via the DVR system network **514** and/or the communication network **508**.

FIG. **6** illustrates various components of an example client device **600** which can be implemented as any form of a computing, electronic, or television system client device in which embodiments of multi-DVR media content arbitration can be implemented. For example, the client device **600** can be implemented as a client device at a DVR node of the multi-DVR system shown in FIG. **1**, and/or as any one of the client devices **510**(**1**-N) shown in FIG. **5** as part of the multi-DVR system **504**.

Client device **600** includes one or more media content inputs **602** which may include Internet Protocol (IP) inputs over which streams of media content are received via an IP-based network. Device **600** further includes communication interface(s) **604** which can be implemented as any one or more of a serial and/or parallel interface, a wireless interface, any type of network interface, a modem, and as any other type of communication interface. A wireless interface enables client device **600** to receive control input commands **606** and other information from an input device, such as from remote control device **608**, a portable computing-based device (such as a cellular phone) **610**, or from another infrared (IR), 802.11, Bluetooth, or similar RF input device.

A network interface provides a connection between the client device **600** and a communication network by which other electronic and computing devices can communicate data with device **600**. Similarly, a serial and/or parallel interface provides for data communication directly between client device **600** and the other electronic or computing devices. A modem facilitates client device **600** communication with other electronic and computing devices via a conventional telephone line, a DSL connection, cable, and/or other type of connection.

Client device **600** also includes one or more processors **612** (e.g., any of microprocessors, controllers, and the like) which process various computer executable instructions to control the operation of device **600**, to communicate with other electronic and computing devices, and to implement embodiments of multi-DVR media content arbitration. Client device **600** can be implemented with computer readable media **614**, such as one or more memory components, examples of which include random access memory (RAM), non-volatile memory (e.g., any one or more of a read-only memory (ROM), flash memory, EPROM, EEPROM, etc.), and a disk storage device. A disk storage device can include any type of magnetic or optical storage device, such as a hard disk drive, a recordable and/or rewriteable compact disc (CD), a DVD, a DVD+RW, and the like.

Computer readable media **614** provides data storage mechanisms to store various information and/or data such as software applications and any other types of information and data related to operational aspects of client device **600**. For example, an operating system **616** and/or other application programs **618** can be maintained as software applications

with the computer readable media **614** and executed on processor(s) **612** to implement embodiments of multi-DVR media content arbitration.

For example, client device **600** can be implemented to include a program guide application **620** that is implemented to process program guide data and generate program guides for display which enable a viewer to navigate through an onscreen display and locate broadcast programs, recorded programs, video on-demand programs and movies, interactive game selections, network-based applications, and other media access information or content of interest to the viewer. The client device **600** can also be implemented to include an arbitration algorithm **622** to implement embodiments of multi-DVR media content arbitration as described herein.

The client device **600** can also include a DVR system **624** with playback application **626**, and recording media **628** to maintain recorded media content **630** which may be any form of on-demand and/or media content such as programs, movies, commercials, music, and similar audio, video, and/or image content that client device **600** receives and/or records. Further, client device **600** may access or receive additional recorded media content that is maintained with a remote data store (not shown), such as from a video-on-demand server, or media content that is maintained at a broadcast center or content provider that distributes the media content to subscriber sites and client devices. The playback application **626** is a video control application that can be implemented to control the playback of media content, the recorded media content **630**, and or other video on-demand media content, music, and any other audio, video, and/or image media content which can be rendered and/or displayed for viewing.

The client device **600** also includes an audio and/or video output **632** that provides audio and video to an audio rendering and/or display system **634**, or to other devices that process, display, and/or otherwise render audio, video, and image data. Video signals and audio signals can be communicated from device **600** to a display device **636** via an RF (radio frequency) link, S-video link, composite video link, component video link, analog audio connection, or other similar communication link. Alternatively, the audio rendering and/or display system **634** can be implemented as integrated components of the example client device **600**.

FIG. **7** illustrates an example entertainment and information system **700** in which an IP-based television environment can be implemented, and in which embodiments of multi-DVR media content arbitration can be implemented. System **700** facilitates the distribution of media content, program guide data, and advertising content to multiple viewers and to multiple viewing systems. System **700** includes a content provider **702** and client systems **704**(**1**-N) each configured for communication via an IP-based network **706**. Each client system **704**(**1**-N) is an example of the client systems **506**(**1**-N) described with reference to FIG. **5**. Each of the client systems **704**(**1**-N) can receive one or more data streams from content provider **702** which are then distributed to one or more other client devices at DVR nodes of a multi-DVR system.

The network **706** can be implemented as a wide area network (e.g., the Internet), an intranet, a Digital Subscriber Line (DSL) network infrastructure, or as a point-to-point coupling infrastructure. Additionally, network **706** can be implemented using any type of network topology and any network communication protocol, and can be represented or otherwise implemented as a combination of two or more networks. A digital network can include various hardwired and/or wireless links **708**(**1**-N), routers, gateways, and so on to facilitate communication between content provider **702** and the client systems **704**(**1**-N). The client systems **704**(**1**-N) receive media content, program content, program guide data, advertising content, closed captions data, and the like from content server(s) of the content provider **702** via the IP-based network **706**.

System **700** includes a media server **710** that receives media content from a content source **712**, program guide data from a program guide source **714**, and advertising content from an advertisement source **716**. In an embodiment, the media server **710** represents an acquisition server that receives the audio and video media content from content source **712**, an EPG server that receives the program guide data from program guide source **714**, and/or an advertising management server that receives the advertising content from the advertisement source **716**.

The content source **712**, the program guide source **714**, and the advertisement source **716** control distribution of the media content, the program guide data, and the advertising content to the media server **710** and/or to other servers. The media content, program guide data, and advertising content is distributed via various transmission media **718**, such as satellite transmission, radio frequency transmission, cable transmission, and/or via any number of other wired or wireless transmission media. In this example, media server **710** is shown as an independent component of system **700** that communicates the program content, program guide data, and advertising content to content provider **702**. In an alternate implementation, media server **710** can be implemented as a component of content provider **702**.

Content provider **702** is representative of a headend service in a content distribution system, for example, that provides the media content, program guide data, and advertising content to multiple subscribers (e.g., the client systems **704**(**1**-N)). The content provider **702** can be implemented as a satellite operator, a network television operator, a cable operator, and the like to control distribution of media content, program and advertising content, such as movies, television programs, commercials, music, and other audio, video, and/or image content to the client systems **704**(**1**-N).

Content provider **702** includes various components to facilitate media data processing and content distribution, such as a subscriber manager **720**, a device monitor **722**, and a content server **724**. The subscriber manager **720** manages subscriber data, and the device monitor **722** monitors the client systems **704**(**1**-N) (e.g., and the subscribers), and maintains monitored client state information.

Although the various managers, servers, and monitors of content provider **702** (to include the media server **710** in one embodiment) are illustrated and described as distributed, independent components of content provider **702**, any one or more of the managers, servers, and monitors can be implemented together as a multi-functional component of content provider **702**. Additionally, any one or more of the managers, servers, and monitors described with reference to system **700** can implement features and embodiments of multi-DVR media content arbitration.

The client systems **704**(**1**-N) can be implemented to include a client device **726** and a display device **728** (e.g., a television, LCD, and the like). A client device **726** of a client system **704** can be implemented in any number of embodiments, such as a set-top box, a digital video recorder (DVR) and playback system, an appliance device, a gaming system, and as any other type of client device that may be implemented in an entertainment and information system. In an alternate embodiment, client system **704**(N) is implemented with a computing device **730** as well as a client device **726**. Additionally, any of the client devices **726** of a client system

704 can implement features and embodiments of multi-DVR media content arbitration as described herein.

Although embodiments of multi-DVR media content arbitration have been described in language specific to features and/or methods, it is to be understood that the subject of the appended claims is not necessarily limited to the specific features or methods described. Rather, the specific features and methods are disclosed as example implementations of multi-DVR media content arbitration.

The invention claimed is:

1. A multi-DVR (digital video recorder) system comprising:

client devices that are each a node of the multi-DVR system and configured for communication with each other;

one or more processors at individual client devices of the client devices to execute an arbitration algorithm configured to arbitrate media content being rendered by the client devices so as not to exceed a media content usage capacity of the multi-DVR system;

the individual client devices configured to:

communicate status messages directly to the client devices to indicate media content being rendered and receive the status messages directly from the client devices;

implement the arbitration algorithm to:

prioritize the media content being rendered by the client devices based at least in part on:

a type of the media content;

an indication of a viewer action associated with the media content being rendered; and

a recency of a media content tune, wherein the recency of the media content tune is determined based on time durations since the client devices have received the indication of the viewer action associated with the media content being rendered; and

based at least in part on prioritizing the media content, determine which of the client devices is rendering a lowest priority media content that can be terminated to provide capacity for rendering higher priority media content at another of the client devices of the multi-DVR system; and

terminate, by a first client device of the client devices, the lowest priority media content based at least in part on determining that the first client device is rendering the lowest priority media content and terminate the lowest priority media content on behalf of a second client device of the client devices based at least in part on determining that the second client device is rendering the lowest priority media content.

2. A multi-DVR system as recited in claim 1, wherein the individual client devices implement the arbitration algorithm to independently determine whether a same client device of the client devices is rendering the lowest priority media content.

3. A multi-DVR system as recited in claim 1, wherein the arbitration algorithm is further configured to arbitrate the media content being rendered by the client devices so as not to exceed a bandwidth capacity of the multi-DVR system.

4. A multi-DVR system as recited in claim 1, wherein the arbitration algorithm is further configured to arbitrate the media content being rendered by the client devices so as not to exceed a maximum number of media content streams in the multi DVR system.

5. A multi-DVR system as recited in claim 1, wherein prioritizing the media content being rendered by the client devices is based at least in part on the recency of the media content tune comprises prioritizing a more recent media content being tuned at a particular client device of the client devices over a previous media content being tuned at a different client device of the client devices.

6. The method of claim 1, wherein prioritizing the media content being rendered by the client devices based at least in part on the indication of the viewer action associated with the media content currently being rendered comprises:

calculating, for the media content being rendered by the individual client devices, time durations since the individual client devices have received the indication of the viewer action associated with the media content being rendered, the viewer action indicating that a viewer is watching the rendered media content; and

based at least on the time durations calculated with respect to the individual client devices, designating the media content having a largest time duration as the lowest priority media content.

7. A multi-DVR system as recited in claim 6, wherein the indication that the viewer is watching the media content is associated with a remote control input.

8. A multi-DVR system as recited in claim 1, wherein the type of the media content comprises one of:

recorded media content,

on demand media content,

live media content, and

picture in picture media content.

9. A method at a client device, the method comprising:

communicating a status message directly to a plurality of client devices that are each a node of a multi-DVR (digital video recorder) system, the status message identifying rendered media content stored at the client device, a type of the rendered media content stored at the client device, an indication of a viewer action associated with the rendered media content stored at the client device, and a recency of a media content tune at the client device, wherein the recency of the media content tune is determined based on a time duration since the client device has received the indication of the viewer action associated with the rendered media content;

receiving additional status messages directly from individual client devices of the plurality of client devices, the additional status messages identifying the rendered media content stored at the individual client devices;

prioritizing the rendered media content stored at the individual client devices based at least in part on the status message;

based at least in part on the prioritizing, determining from the additional status messages which of the individual client devices is storing a lowest priority stored media content that can be deleted to provide storage capacity for higher priority media content at another of the individual client devices of the multi-DVR system; and

deleting the lowest priority stored media content based at least in part on determining that the client device is storing the lowest priority stored media content and deleting the lowest priority stored media content on behalf of a different client device of the plurality of client devices based at least in part on determining that the different client device is storing the lowest priority stored media content.

10. A method as recited in claim 9, further comprising:

determining that the client device is storing the lowest priority stored media content; and

based at least in part on the determining that the client device is storing the lowest priority stored media content, deleting the rendered media content stored at the client device.

11. A method as recited in claim **9**, further comprising executing an arbitration algorithm to determine which of the individual client devices is storing the lowest priority stored media content that can be deleted.

12. A method as recited in claim **11**, wherein the individual client devices execute the arbitration algorithm to independently determine that a same client device of the plurality of client devices is storing the lowest priority stored media content that can be deleted.

13. A method as recited in claim **9**, further comprising arbitrating the rendered media content stored by the individual client devices so as not to exceed a bandwidth capacity of the multi-DVR system.

14. A method as recited in claim **9**, further comprising arbitrating the rendered media content stored by the individual client devices so as not to exceed a maximum number of media content streams in the multi DVR system.

15. A method as recited in claim **9**, wherein prioritizing the rendered media content stored at the individual client devices based at least in part on the status message and the additional status messages comprises prioritizing a stored media content being tuned more recently at a first client device of the plurality of client devices over a previously tuned stored media content at a second client device of the plurality of client devices to determine which of the individual client devices has the lowest priority stored media content that can be deleted.

16. A device comprising;

a processor; and

an arbitration algorithm that, when executed by the processor, directs a particular client device of a plurality of client devices to:

arbitrate media content stored by the plurality of client devices of a multi-DVR (digital video recorder) system so as not to exceed a media content storage capacity of the multi DVR system, individual client devices of the plurality of client devices being configured to communicate directly with one another;

prioritize the media content stored by the individual client devices based at least in part on a type of the media content, an indication of a viewer action associated with the media content, and a recency of a media content tune, wherein the recency of the media content tune is determined based on time durations since the individual client devices have received the indication of the viewer action associated with the media content;

determine which of the individual client devices has a lowest priority stored media content that can be deleted to provide capacity for higher priority media content at another one of the individual client devices; and

delete the lowest priority stored media content based at least in part on determining that the particular client device is storing the lowest priority stored media content and delete the lowest priority stored media content on behalf of a an individual client device of the individual client devices based at least in part on determining that the second client device is storing the lowest priority stored media content.

17. The device as recited in claim **16**, wherein determining which of the individual client devices has the lowest priority stored media content comprises:

calculating, for individual media content items of the media content stored by the individual client devices, a time duration that corresponds to an amount of time that has expired since the individual client devices have received a viewer action associated with the individual media content items; and

based at least on the time durations for the individual media content items, designating a particular individual media content item of the individual media content items having a largest time duration as the lowest priority stored media content.

18. The device as recited in claim **16**, wherein the arbitration algorithm is further executable to direct the particular client device to arbitrate the media content rendered by the plurality of client devices so as not to exceed a bandwidth capacity of the multi-DVR system.

19. The device as recited in claim **16**, wherein the arbitration algorithm is further executable to direct the particular client device to arbitrate the media content rendered by the plurality of client devices so as not to exceed a maximum number of media content streams in the multi DVR system.

20. The device as recited in claim **16**, wherein:

the arbitration algorithm is further executable to direct the particular client device to receive status messages directly from the individual client devices, the status messages indicating media content being rendered at the individual client devices; and

the media content rendered by the individual client devices is arbitrated independently by the independent client devices based on the received status messages.

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